

**SOME PLEISTOCENE MOLLUSKS OF SAN
QUINTIN BAY AND OTHER LOCALITIES
FROM LOWER CALIFORNIA**

(Abstract)

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THE GEOLOGY OF SAN QUINTIN BAY

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San Quintin Bay is a shallow and tortuous inlet on the west coast of Lower California about 150 miles south of San Diego. It is surrounded by level plains, elevated but a few feet above the sea, and extending for several miles inland to the foot of the mountains. It is protected from the ocean on the west side by a chain of low hills.

The best account of the geology of the region is given by Hanna.¹

"In the late Pleistocene the present bay was a broad indentation of the sea, and ocean living species were very abundant. Subsequent elevation raised the bottom on the east side in a broad fold. The preservation of the fossils is excellent, many of them retaining some of the original coloration. How far back towards the foothills this embayment extended can not be determined but probably it went to the first terrace, the beginning of a long series of rolling hills or mesas. This terrace is also said to contain fossils, but none were secured. It is probably much older than the outcrops on the bay. The mountainous country to the east of this terrace is metamorphic, the age not having been determined.

"On the west side of the bay there is a chain of low volcanic cones, not over 300 feet high. Lava has spread northward from these as far as the bay shore and on top of a broad shelf of this there are other Pleistocene marine sediments, but with a different set of fossils (also Pleistocene)."

Evidently the most fossiliferous locality along the eastern shore of the bay is just south of the village where Hanna (op. cit.) "succeeded in getting a very large collection of

¹ Hanna, G. D. Proc. Cal. Acad. Sci., Ser. 4, Vol. 19, pp. 246-7, 1925.

fossil shells containing several thousand specimens" from a series of low cliffs in soft fossiliferous sand.

Jordan² writes that "those species recorded by Dall but not recognized in Hanna's collection were apparently taken from several points about the bay, but all belong without question to one horizon."

THE AGE OF THE SAN QUINTIN BAY DEPOSITS

Jordan³ lists the molluscan fauna reported from San Quintin Bay as comprising 93 pelecypods, 157 gastropods, 2 amphineura, making a total of 256. In addition the deposits contain a few species of Bryozoa, Echinodermata, and Crustacea, and many species of Foraminifera. Jordan (op. cit., p. 247) states that only 13 or about 5 per cent of the molluscan species are not known to be living today. Several of these are closely allied to the recent forms and our knowledge of the present day fauna of Lower California is not sufficiently complete to assume that a few shells will not eventually be found in a living state.

The molluscan fauna collected by Orcutt from San Quintin Bay comprises 113 molluscan species, 70 of which are pelecypods, 42 gastropods, and 1 scaphopod. All of these, except two new species of pelecypods, are known to be living at present; a good many of these, however, inhabit waters only to the north or south of San Quintin Bay. It is possible, of course, that the two new pelecypod species may be later found to be living somewhere in this general region.

By reason of the small number of extinct species of molluscs, Jordan (op. cit., p. 248) concludes that these deposits can not be older than the Upper Pleistocene. He correlates them with the Upper San Pedro deposits of San Pedro, California, by the following arguments:

² Jordan, E. K., Proc. Cal. Acad. Sci., Ser. 4, Vol. 15, p. 293, 1926.

³ Jordan, E. K., Proc. Cal. Acad. Sci., Ser. 4, Vol. 15, pp. 245-7, 1926.

"It has been proved by Arnold, and again brought out by J. P. Smith that on the basis of contrasting faunas dependent upon climatic changes two distinct horizons may be recognized in the Pleistocene of San Pedro. The older, known as the lower San Pedro, contains a cold-water fauna of which many species now live only to the north of that district. The younger or upper San Pedro, contains a sub-tropical fauna, of which many specimens are today confined to the coast of Lower California, and to the Gulf. During the lower Pleistocene, then, as during the uppermost Pliocene, the climate of Western North America was distinctly cooler than it is at present, while later in the Pleistocene it became warmer than today.

"The deposits at San Quintin, containing a fauna with several warmer water elements in a latitude where such a fauna no longer exists are, therefore, to be placed in the Upper Pleistocene, as an approximate though more southern equivalent of the Upper San Pedro. In addition to the evidence deduced from climatic relations, there remains in support of such correlation the fact that, with few exceptions, the species occurring at San Quintin are also common to the Upper San Pedro, and far fewer of them are found in older formations."

Smith,⁴ on the other hand, characterizes the entire Quaternary period as containing few species that today are extinct, but many that are extinct locally. He does not hesitate to place in the Lower Pleistocene a limited molluscan faunule of 38 species from Magdalena Bay, Lower California, although none of the species are extinct. The principal basis of his correlation of this and other Lower California west coast deposits of probable Quaternary age is that of taking into account the present distribution of forms that no longer live in those localities.

⁴ Smith, J. P. Proc. Cal. Acad. Sci., Ser. 4, Vol. 9, p. 128, 1919.

Eaton⁵ has demonstrated, however, that in the Ventura Basin of Southern California, the equivalent of the Lower San Pedro Series is separated from that of the Upper San Pedro by a considerable period of time. Specifically, enough time must have elapsed to allow for the erosion of 5,000 feet of sedimentary rocks. Although Eaton conservatively estimates this time interval at a million years, the Lower Pleistocene faunas of the Ventura Basin are reported as only 7.4 per cent extinct by Eaton and 1.8 to 4 per cent extinct by Arnold.

Eaton (op. cit., p. 122) maintains that "the critical change in life occurred sharply at the base of the Saugus" (Las Posas formation of Pressler)⁶ which comprises 1,750 of the 2,500 feet of Pleistocene sediments in the Ventura Basin. He points out that "the change in lithology is locally very noticeable but similar changes were present during parts of Pleistocene time, and yet the faunal change in the basal 100 feet of the transition zone was greater than that in the 6,000 or more feet of Pliocene strata. The extinct Pliocene forms are, moreover, most often found in Southern California in those Pliocene beds whose lithology and depth of deposition resembled that of the post-Pliocene sediments."

⁵ Eaton, J. E. Bulletin American Association Petroleum Geologists, Vol. 12, No. 2, pp. 111-141, Febr., 1928.

⁶ Since this paper was written, Grant and Gale's "Memoir of the San Diego Society of Natural History," cataloging the Pliocene and Pleistocene mollusca of California, has been published. The authors believe that practically none of the early Pleistocene mollusca are universally extinct but that alternations of colder and warmer waters in a given region have changed the composition of the fauna in that region, with the displacement of some species to other localities. They divide the Pleistocene below the great unconformity into three units, namely, a basal Las Posas, an intermediate Timms Point, and an upper San Pedro zone (= lower San Pedro of Arnold). The fauna of the intermediate zone indicates warmer water conditions, and the faunas of the upper and lower zones a cool water environment. The Palos Verdes (= upper San Pedro of Arnold) was deposited subsequently to the great deformation, and in warmer waters.

Eaton recognizes the equivalent of the Saugus below the Lower San Pedro Series at the type locality, San Pedro, but evidently considers it less than half as thick as the Saugus in the Ventura Basin.

Eaton (op. cit., p. 123) has found that "the San Pedro formation grades up from the Saugus formation in the deeper parts of Ventura and Los Angeles basins in a manner that makes the precise contact difficult to ascertain."

In the Ventura Basin the San Pedro formation of Eaton (or the Lower San Pedro Series of Arnold) are found by Eaton (op. cit., p. 123) to include "strata at its base which resemble those at the typical locality on the San Pedro crustal block." Above these beds are overlying and apparently conformable strata, eroded at the typical locality, which contain warmer and more modern faunas than are present at the type. The upper or additional strata in Ventura Basin represent a small part of the enormous interval of erosion which separates the San Pedro and Palos Verdes (= Upper San Pedro Series of Arnold) at the typical locality.

An idea of the length of the erosion interval of the Middle Pleistocene is afforded by the geologic history of the several Californian basins of Cenozoic deposition. This interval is termed the "Sierran" by Eaton and is used as more or less synonymous with the term Ozarkian, proposed by Hershey in 1896 for the long interval of Quaternary erosion in North America which apparently preceded the invasion of the first ice sheet.

Eaton (op. cit., p. 131) states that "Sierran time reveals, in California, some of the grandest structural effects recorded in the Cenozoic era. The Pacific geosynclinal belt, with its prodigious thickness of sediments, was crushed between comparatively rigid segments of the lithosphere, and was shattered in such a manner that much of the resulting geology is complex and difficult to unravel." . . . "The smaller blocks were caught between the larger ones and were severely

deformed. Ventura Basin was overridden from the north and south, and was split into fragments. The 19,832-foot section . . . was possibly tilted almost to its present inclination, and the strata farther west . . . folded into a steeply dipping anticline."

. . . "Miocene strata were locally thrust over Pliocene sediments for a distance estimated to be $3\frac{1}{2}$ miles. On the north, a series of overthrusts reversed the stratigraphic sequence, for Miocene rests on Pliocene, Oligocene on Miocene, and Eocene on Oligocene, with Eocene locally overthrust on Pliocene and cutting out the intervening series. The foregoing may give some idea of the Sierran deformation of parts of California, of the forces which caused most of the structure now yielding petroleum to be formed, and of why California strata locally have extremely high dips."

The method of estimating the age of Pleistocene sediments by means of the percentage of recent species contained in the deposits has been in question for some time.

Eaton's work again emphasizes the fact that this method is very uncertain; for he points out that the faunas of the lowest Pleistocene of the Ventura Basin range from 1.8 per cent to 7.4 per cent extinct.

The molluscan fauna of the San Quintin Bay deposits is composite, containing species that today range only north or south of San Quintin Bay as well as those that range both north and south. Thus it would seem that these deposits were laid down before the present climatic zones were firmly established or before the species had separated into warmer and cooler water groups. In any event, these deposits are very probably older than the Palos Verdes of Eaton and Grant and Gale (= Upper San Pedro Series of Arnold).

It seems, however, that a detailed survey along the coast from San Pedro to San Quintin might do most to solve the problem of the age of the San Quintin deposits.

GENERAL DISCUSSION OF THE ECOLOGY OF
THE SAN QUINTIN DEPOSITS

Stearns⁷ has remarked "that a striking feature in the conchological fauna of the Pacific Coast, included in the Californian and Vancouver zoological province, when compared with the molluscan fauna of the Atlantic Coast from the Arctic Seas to Georgia, is the preponderance in the former of those forms of molluscan life which are embraced in the order Scutibranchiata."

The Scutibranchiate gastropods, or shield gilled crawlers, comprise a great number of molluscs, all of which are marine and which inhabit the sea shore, principally the littoral and laminarian zones, subsisting on marine vegetation; *Calliostoma*, for example, on the larger algae; *Trochiscus* (*T. sowerbyi*) and *Chorostoma* crawling over the rocks upon which grows the green *Cladophora* or some allied vegetable form upon which it feeds, and which is also the favorite food of several species of limpets.

In the San Quintin fauna *Astraea undosus* Wood is abundant, and altogether there are 11 species of the 42 (gastropods) falling in this group.

In attempting to determine the ecological conditions of a fossil fauna, one is confronted with serious handicaps. In the first place there is a dearth of information concerning the constitution of existing shallow-water faunas. At best there are little more than observations on the habitat of single species in scattered localities. Moreover, information regarding the effect that different bottoms have on existing faunas is lacking. In the Biological survey of Woods Hole and Vicinity⁸ there are given lists of species taken from three kinds of bottoms, viz., sand, gravel, and stones and mud. As practically all the gastropods and pelecypods are found on

⁷ Stearns, R. E. C., Proc. Cal. Acad. Sci., Oct. 7, 1872.

⁸ Bull. Bureau of Fisheries, Vol. 31, pt. 1, pp. 70, 71, 72, 1911.

all three bottoms, it is evident how difficult it is to draw distinctions between the life of the various bottoms.

Certain general conclusions, however, may be drawn concerning the environmental conditions of the San Quintin deposits.

The faunal assemblage indicates very shallow depths, practically a littoral environment, with the temperature of the waters probably somewhat but not greatly different from the present.

The species most abundantly represented in the San Quintin are those that today range both to the north and to the south of that region. This is particularly so among the pelecypods. Of 13 more numerous represented species, distributed among as many genera, only three at present do not range as far south as San Quintin Bay. Yet all of these are found as far south as San Diego, California. Only one pelecypod species, *Pecten hindsii* Carpenter, and one gastropod, *Acteocina culcitella* Gould, do not range as far south as San Diego, the southern limit of the former being at Monterey, of the latter in Puget Sound.

Those species that now range only north or south of San Quintin Bay are only sparingly represented in the San Quintin Bay deposits. This applies more particularly to those species now living only to the south; both the number of species and specimens are fewer. This distribution should not be interpreted as indicating that the waters were cooler than at present, for although 22 of the 70 pelecypod species and 9 of the 42 gastropod do not range as far south as San Quintin Bay, yet practically all have their southern range in the Southern California subprovince that includes also the region around San Quintin Bay. On the other hand, the six pelecypod and two gastropod species that range only south of San Quintin Bay are properly included in a different, warmer-water subprovince, i.e., the "Gulf of California," ranging from Cerros Island, Lower California, to

Panama. Hence it would seem that if any deduction is to be drawn from the present distribution of San Quintin species as to the temperature of the waters of San Quintin time, it is more probable that the waters were warmer, rather than cooler, than at present. If such be the case, however, the anomaly arises that the colder-water forms retreated northward as the water cooled during post-San Quintin times.

Orcutt's collection from San Quintin Bay contains only slightly more than half as many gastropod as pelecypod species, whereas an outstanding characteristic of warm seas is the greater number of gastropods. Jordan's⁹ list of the fossils from San Quintin Bay, however, shows that the number of gastropod species does predominate.

That the waters were very shallow is indicated by the fact that the species with the most numerous representatives are those that inhabit shallow depths. The favored habitat of some of these is in a foot or two of mud or sandy mud between tides, or at low water. The great scarcity of deeper-water forms and of those that affect rocky or gravelly regions, as well as the prevailing composition of the fauna, indicates a probable environment of very shallow water and a sandy mud bottom.

SPECIES ABUNDANTLY REPRESENTED IN THE SAN QUINTIN BAY DEPOSITS

Pecten latiauritus Conrad, Monterey, California to Lower California.

Hinnites giganteus Gray, Aleutian Islands to Magdalena Bay.

Phacoides nuttallii Sowerby, Oregon to Chile.

Diplodonta orbella Gould, Pribiloff Islands to Gulf of California.

Tivela stultorum Mawe, Santa Cruz, California to Socorro Islands.

Amiantis callosa Conrad, San Pedro, California to Gulf of Tehauntepec.

⁹ Jordan, E. K. Proc. Cal. Acad. Sci., Ser. 4, Vol. 15, pp. 245-7, 1926.

- Saxidomus nuttallii* Conrad, Baulinas Bay to San Diego.
Paphia lacineata Conrad, Unalaska to San Diego, California.
Tellina bodegensis Hinds, Queen Charlotte Islands to Gulf of California.
Macoma secta Conrad, Vancouver Island to Gulf of California.
Spisula planulata Conrad, Monterey to Cape San Lucas.
Schizothaerus nuttallii Conrad, Wrangell, Alaska, to San Diego.
Dentalium neohexagonum Sharpe & Pilsbry, Monterey, California to Guacomayo, Central America.
Bullaria gouldiana Pilsbry, Santa Barbara, California to Mazatlan, Mexico.
Olivella biplicata fucana Oldroyd, Str. San Juan de Fuca to San Diego.
Olivella pedroana Conrad, Puget Sound to Cape San Lucas.
Olivella boetica Carpenter, Kodiak Island to Cape San Lucas.
Kellettia kelletti Forbes, Santa Barbara, California, to San Quintin Bay.
Macron aethiops Reeve.
Murex festiva Hinds, Santa Barbara, California, to Cerros Islands.
Acanthina lugubris Sowerby, San Diego, California, to Magdalena Bay.
Crepidula onyx Sowerby, Monterey, California, to Panama.
Astraea undosus Wood, Laguna Beach, California, to Cerros Islands.

SPECIES REPORTED LIVING ONLY NORTH OF
SAN QUINTIN BAY ¹⁰

- Pecten diegenis* Dall, Monterey to San Diego, California.
† *Pecten hindsii* Carpenter, Bering Sea to Monterey, California.
Lyonsia californica Conrad, Puget Sound to Todos Santos Bay, Lower California.
Phacoides annulata Reeve, Port Althrop, Alaska, to Coronado Islands.
Phacoides tenuisculpta Carpenter, Minivak Islands to Coronado Islands.

¹⁰ NOTE: The dagger (†) indicates those species that do not range as far south as San Diego.

- Kellia laperousii* Deshayes, Bering Sea to San Diego, California.
- Cardium quadregenarium* Conrad, Santa Barbara, California, to Todos Santos Bay, Lower California.
- Cardium corbis* Martyn, Bering Sea to San Diego, California.
- Saxidomus nutalli* Conrad, Baulinas Bay to San Diego, California.
- Paphia staminea lacineata* Carpenter, Unalaska to San Diego, California.
- Paphia tenerrima* Carpenter, Puget Sound to San Quintin Bay.
- Tellina idae* Dall, Santa Barbara Islands to San Pedro, California.
- Metis alta* Conrad, Santa Barbara to San Diego, California.
- Semele decisa* Conrad, San Pedro to San Diego, California.
- Donax laevigata* Deshayes, San Luis Obispo to San Diego, California.
- Siliqua lucida* Conrad, Monterey, California, to Todos Santos Bay, Lower California.
- Solen sicarius* Gould, Vancouver Island to San Quintin Bay.
- Mactra californica* Conrad, Neah Bay to San Diego, California.
- Spisula cattilliformis* Conrad, Neah Bay to San Diego, California.
- Schizothaerus nutalli* Conrad, Wrangell Island to San Diego, California.
- Panopea generosa* Gould, Puget Sound to San Diego, California.
- Zirfaea gabbi* Tryon, Bering Sea to San Diego, California.
- †*Acteocina culcitella* Gould, Kodiak Island to Puget Sound.
- Olivella biplicata fucana* Oldroyd, Str. of San Juan de Fuca to San Diego, California.
- Kellettia kelletti* Forbes, Santa Barbara, California, to San Quintin Bay.
- Cerithidea californica* Haldeman, Baulinas Bay to San Diego, California.
- Polinices recluzianus alta* Dall, Monterey to Catalina Island, California.
- Polinices recluzianus imperforata* Stearns, Crescent City to San Diego, California.
- Acmaea persona* Eschscholtz, Shumagon Islands to Socorro Islands.

Calliostoma costatum Martyn, Sitka, Alaska, to San Diego, California.

Diodora aspera densiclathrata Reeve, Monterey, California, to San Quintin Bay.

SPECIES REPORTED LIVING ONLY SOUTH OF
SAN QUINTIN BAY

Pecten cataractes Dunker, Gulf of California.

Macrocallista aurantiaca Sowerby, Gulf of California, Cape San Lucas, to Payta, Peru.

Protothaca sulculosa Dall, San Ignacio Lagoon, Lower California.

Tellina viridotincta Carpenter, Lower California to Panama.

Macoma elongata Hanley, San Quintin Bay to Panama.

Cardium procerum Sowerby, Lower California from vicinity of Cerros Island, south to Ecuador and Payta, Peru.

Myurella armillata Hinds, Magdalena Bay to Panama.

Cerithidea mazatlanica Carpenter (?), Mazatlan, Mexico.

BIOLOGICAL AND ECOLOGICAL DATA OF THE
SAN QUINTIN FAUNA

The chief sources for the data included in the following pages are Dall's "Catalogue of the Shell-bearing Marine Molluscs and Brachiopods of the southeastern coast of the United States,"¹¹ his several volumes on the tertiary fauna of Florida,¹² the lists and the descriptions of species of the earlier California naturalists, particularly Gabb, Carpenter, Sowerby and Conrad, and Fischer's *Manuel de Conchyliologie*.¹³

All the species of the San Quintin Bay fauna are listed whether data as to the range, etc., is available or not. Immediately after the name of the species is given the number of pelecypod valves or gastropod shells in the collection.

Genus Leda

¹¹ Dall, W. H. U. S. Nat. Mus. Bull. 37, 1889.

¹² Dall, W. H. Trans. Wagner Free Inst. Sci., Vol. 3, 1898-1903.

¹³ Fischer, Paul. Man. de Conch., Paris, 1887.

The maximum distribution of the species of this genus is in the Arctic seas, but some occur also in temperate and tropical latitudes. The depth of habitat varies greatly, *L. messanensis* Seguenza, for instance, having been reported by Dall as ranging from 32 to 2,033 fathoms. In general, the depth of habitat decreases in the northern range.

1. *Leda taphria* Dall. 2 valves.

Range: Bodega Bay, Calif., to L. Calif.

Genus Arca—Subgenus *Scapharca*

This group inhabits warm, prevailing shallow water. Dall records none from below forty fathoms on the southeast coast of the United States.

1. *Arca multicosta* Sowerby. 7 valves.

Range: San Diego, Calif., to the Gulf of Calif. Dredged from a depth of twelve fathoms, Gulf of Tehuantepec.

Genus Pecten—Subgenus *Pecten* s. s.

Most of the species of the subgenus *Pecten* s. s. inhabit shallow water, although some do not appear above fifty fathoms. This group as a whole inhabits warm water, but some species are found in cold water.

1. *Pecten diegensis* Dall. 1 valve.

Range: Monterey to San Diego, Calif., and the Cortez Bank.

Subgenus *Euvola*

2. *Euvola cataractes* Dall. 12 valves.

Range: Gulf of California.

Subgenus *Chlamys*

3. *Chlamys* (*Chlamys*) *hindsii* Carpenter. 2 valves.

Range: Bering Sea to Monterey, Calif.

4. *Chlamys* (*Leptopecten*) *latiauritus* Conrad. About 50 valves.

Range: Monterey, Calif., to L. Calif.

5. *Chlamys* (*Plagioctenium*) *circularis* Sowerby. 6 valves.

Range: Gulf of California.

Plagioctenium inhabits warm waters.

Genus Hinnites

1. *Hinnites giganteus* Gray. 20 valves.

Range: Aleutian Islands to Magdalena Bay, L. Calif.

Genus Pododesmus

1. *Pododesmus machroschisma* Deshayes. 8 valves.

Range: Bering Sea to Southern California, in shallow water.

Genus Lyonsia

The species of the family Lyonsiidae are nearly all nestlers. The genus *Lyonsia* occurs in both shallower and deeper waters, and ranges from cold to warm waters.

1. *Lyonsia californica* Conrad. 5 valves.

Range: Puget Sound to Todos Santos Bay, L. Calif.

Genus Pandora

1. *Pandora punctata* Conrad.

Range: Vancouver Island to Gulf of Calif.

Baulinas Bay to San Diego in moderate depths.

Genus Cardita

"The species of the family Carditidae seem to affect rocky or gravelly regions from low water to moderate depths, rarely exceeding 100 fathoms except in a few cases, where shallow water Arctic or boreal species follow the cold water southward into gradually increasing depths. The mytiloid forms, including the genus *Cardita* are restricted to the warmer seas." (Dall.)

1. *Cardita subquadrata* Carpenter. 2 valves.

Range: Queen Charlotte Islands to Todos Santos Bay, L. Calif.

Genus Chama

A sessile genus, found at low water to 287 fathoms, deeper and shallower water forms occur together in the same latitude. Inhabits the warmer seas.

1. *Chama pellucida* Sowerby. 30 valves.

Range: Oregon to Chile and the Galapagos Islands.

Genus Phacoides

1. *Phacoides* (Here) *richthofeni* Gabb. 12 valves.

Range: Catalina Island to Gulf of California in 16 to 36 fathoms.

2. *Phacoides* (*Lucinisca*) *nutalli* Conrad. 60 valves.

Range: Santa Barbara, Calif., to Mazatlan, Mexico, in 16 to 30 fathoms.

3. *Phacoides* (*Lucinoma*) *annulata* Reeve. 2 valves.

Range: Port Althrop, Alaska, to Coronado Islands in 8 to 135 fathoms.

4. *Phacoides* (*Parvilucina*) *tenurisculpta* Carpenter. 4 valves.

Range: Nunivak Island (Bering Sea) to Coronado Islands, L. California, in 8 to 135 fathoms.

Genus Diplodonta

There is probably little correlation between the depth of habitat and the latitude of occurrence among the species of this genus. Inhabiting shallow to moderate depths in cool to warmer water with a preference for the latter.

1. *Diplodonta orbella* Gould. 36 valves.

Range: Pribiloff Islands, Bering Sea, to Gulf of Calif., in 5 to 30 fathoms.

Superfamily Leptonacea

This group contains a great many commensal nestling or parasitic forms, if independent, usually very active, crawling like gastropods on a subreptary foot.

Genus Kellia

Inhabiting generally cooler waters.

1. *Kellia laperousii* Deshayes. Several Fragments.

Range: Bering Sea to San Diego, Calif.

Genus Cardium—Subgenus *Trachycardium*

1. *Cardium* (*Trachycardium*) *quadregenarium* Conrad. 30 valves.

Range: Santa Barbara, Calif., to Todos Santos Bay, L. Calif., in 24 to 60 fathoms.

Subgenus *Ringicardium*

Circumtropical.

2. *Cardium* (*Ringicardium*) *procerum* Sowerby. 8 valves.

Range: Cerros Island, L. Calf., to Ecuador and Payta, Peru.

Subgenus *Cerastoderma*3. *Cardium* (*Cerastoderma*) *corbis* Martyn. 2 valves.

Range: Bering Sea to San Diego, Calif. Japan. In 8 to 15 fathoms, California. In stomach of starfish, at 12 fathoms, California.

Subgenus *Laevicardium*

Circumtropical.

4. *Cardium* (*Laevicardium*) *substriatum* Conrad. 2 valves.

Range: Catalina Island and San Pedro, Calif., to Acapulco, Mexico.

5. *Cardium* (*Laevicardium*) *elatum* Sowerby. 5 valves.

Range: San Pedro, Calif., to Panama.

Genus Dosinia

Inhabiting cooler and warmer waters at prevailingly shallow depths.

1. *Dosinia ponderosa* Gray. 12 valves.

Range: San Diego, Calif., to Payta, Peru.

Genus Macrocallista

On the west coast of North America this is a shallow water tropical form.

1. *Macrocallista aurantiaca* Sowerby. 8 valves.

Range: Gulf of Calif., Cape St. Lucas to Guayaquil in 10 to 18 fathoms.

Genus Tivela

Inhabits warmer waters.

1. *Tivela stultorum* Mawe. 27 valves.

Range: Santa Cruz to Socorro Island and perhaps Mazatlan, Mex.

*Genus Amiantis*1. *Amiantis callosa* Conrad. Very many valves.

Range: San Pedro, Calif., to Gulf of Tehuantepec. Common at low water. One of the most characteristic species of the Southern Californian coast.

Genus Saxidomus

Inhabits the American and Asiatic shores of the North Pacific.

1. *Saxidomus nuttallii* Conrad. Very many valves.

Range: Baulinas Bay to San Diego, Calif. Burrows into soft clay-stone, accompanying the *Pholades*, *Cumingia*, etc.

Genus Chione

A warmer water to tropical genus, ranging from shallow depths to a maximum of 125 fathoms.

1. *Chione undatella* Sowerby. 9 valves.

Range: San Pedro, Calif., to Guayaquil, Ecuador. Found "on the shore" by G. B. Sowerby.

2. *Chione succinta* Valenciennes. 7 valves.

Range: San Pedro, Calif., to Panama.

3. *Chione picta* Dall. 2 valves.

Genus Anomalocardia

Inhabiting warmer to tropical waters at shallow depths.

1. *Anomalocardia subrugosa* Manger. 1 valve.

Genus Paphia—Subgenus *Protothaca*

Inhabits cooler to warmer water, but with a tendency to favor the latter.

1. *Paphia staminea lacineata* Carpenter. 40 valves.

Range: Unalaska to San Diego, Calif. *Tapes staminea* Conrad has been reported living two feet deep in mud, between tides; also 12 to 20 inches deep in sandy mud.

2. *Paphia staminea sulculosa* Dall. 1 valve.

Range: San Ignacio Lagoon, Lower Calif.

3. *Paphia tenerrima* Carpenter. 12 valves.

Range: Puget Sound to San Quintin Bay.

Genus Cooperella

Inhabits the west coast of America.

1. *Cooperella subdiaphana* Carpenter. 1 valve.

Range: Queen Charlotte Island to Gulf of Calif.

Genus Tellina

The species of *Tellina* in the broad sense are predominantly very shallow water forms and are found in all seas. Those on the southeast coast of North America are a quite homogeneous group as regards both shallow and warmer water, only 3 of 23 having been found at more than fifty fathoms and only (of 23) north of Cape Hatteras. The whole group of *Tellinacea* corresponding to San Quintin genera are shallow water forms.

1. *Tellina idae* Dall. 1 valve.

Range: Santa Barbara Islands and San Pedro, Calif., in 16 to 38 fathoms.

2. *Tellina viridotincta* Carpenter. 1 valve.

Range: Lower California to Panama.

3. *Tellina bodegensis* Hinds. More than 100 valves.

Range: Queen Charlotte Island to Gulf of Calif. Japan.

Genus Metis

1. *Metis alta* Conrad. 11 valves.

Range: Santa Barbara to San Diego, Calif.

Genus Macoma

Inhabits all seas; usually in shallow water.

1. *Macoma nasuta* Conrad. 4 valves.

Range: Kodiak Island to Scammon Lagoon, L. Calif.
In 3 feet of mud between tide marks.

2. *Macoma acolasta* Dall. More than 90 valves.

3. *Macoma elongata* Hanley. 2 valves.

Range: Lower Calif. (lat. $30^{\circ}36'$) to Panama, in 14 to 30 fathoms.

4. *Macoma* (*Rexithaerus*) *indentata* Carpenter.

Range: Puget Sound to Lower California.

5. *Macoma secta* Conrad. 40 valves.

Range: Vancouver Islands to Gulf of Calif. In 12 to 20 inches of sandy mud at low water, with *M. nasuta* Conrad and *Paphia staminea* Conrad.

Genus Semele

A distinctly warmer water group, living at shallow depths in sand and mud. Species of this group clearly give evidence of approaching the surface in their northern range.

1. *Semele decisa* Conrad. 2 valves.

Range: San Pedro to San Diego, Calif.

2. *Semele pulchra* Sowerby. 12 valves.

Range: Santa Barbara to San Diego, Calif.

3. *Semele quentinensis* Dall. 10 valves.

Genus Cumingia

Ranging from cooler to warmer waters; inhabiting shallow depths.

"The species of this genus are nestlers, intimately related to *Scrobicularia*, which lives in sandy places, which it represents on the American coast. It never burrows in hard substances but often occupies those made by true borers and in this way exhibits a great diversity of outline." (Dall.)

1. *Cumingia lamellosa* Sowerby. 3 valves.

Range: Crescent City, Calif., to Payta, Peru.

2. *Cumingia densilineata* Dall. About 36 valves.

Genus Sanguinolaria

Inhabiting warmer seas.

1. *Sanguinolaria orcutti* Dall. 40 valves.

Genus Donax

This is a littoral genus, living in the sand. It inhabits temperate and tropical waters.

1. *Donax californica* Conrad. 2 valves.

Range: San Pedro, Calif., to Panama.

2. *Donax laevigata* Deshayes. 2 valves.

Range: Santa Barbara, Calif., southward.

Superfamily Solenacea

These are dwellers in soft bottoms, narrow, elongated, modified for burrowing.

Genus Solen

Inhabiting shallow depths in nearly all seas, the species showing a tolerance for a wide range in temperature.

1. *Solen sicarius* Gould. 4 valves.

Range: Vancouver Island to San Quintin Bay.

2. *Solen rosaceus*. 6 valves.

Range: Santa Barbara, Calif., to Gulf of California.

Genus Siliqua

Inhabiting both cooler and warmer waters.

1. *Siliqua lucida*.

Range: Monterey, Calif., to Todos Santos Bay, L. Calif.

Genus Mactra (including *Spisula*)

Universally distributed, inhabiting sandy shores, at slight depth.

1. *Mactra californica* Conrad. 3 valves.

Range: Neah Bay, Washington, to San Diego, Calif.

Inhabits muddy marshes, bare at low water, near Santa Barbara, Calif.

2. *Spisula hemphilli orcutti* Manger. 4 valves.

3. *Spisula cattilliformis* Conrad. 6 valves.

Range: Neah Bay, Wash., to San Diego, Calif.

4. *Spisula planulata* Conrad. About 50 valves.

Range: Monterey to Cape San Lucas. In muddy marshes bare at low water, with *Mactra californica* Conrad.

5. *Spisula longa* Dall. 8 valves.

Genus Schizothaerus

Inhabiting the North Pacific.

1. *Schizothaerus nutalli* Conrad.

Range: Wrangell, Alaska, to San Diego, Calif. Inhabits salt marshes bare at low water in the vicinity of Santa Barbara.

Genus Cryptomya

Inhabiting cool temperature to warmer water, but with a preference for the latter.

1. *Cryptomya californica* Conrad. 1 valve.

Range: Chichagoff Island, Alaska, to Topobolampo, Mexico.

2. *Cryptomya magna* Dall. 16 valves.

Genus Corbula

Inhabiting usually warmer, shallow to rather deep water.

1. *Corbula luteola* Carpenter. 6 valves.

Range: Monterey, Calif., to Magdalena Bay.

Genus Panopea

Ranging from cooler to warmer waters.

1. *Panopea generosa* Gould. 12 valves.

Range: Puget Sound to San Diego, Calif.

Genus Saxicava

Universally distributed.

1. *Saxicava arctica* Linné.

Range: Arctic Ocean to Panama. Almost universal in temperate and cold seas. Not found below 100 fathoms.

Genus Zirfaea

Universally distributed.

1. *Zirfaea gabbi* Tryon. 1 valve.

Range: Bering Sea to San Diego, Calif.

Genus Dentalium

Universally distributed. Some of the larger forms are abyssal.

1. *Dentalium neohexagonum* Sharp and Pilsbry. 70 shells.

Range: Monterey, Calif., to Guacomayo, Central America.

Genus Acteocina

Inhabits southern waters at very shallow depths.

1. *Acteocina culcitella* Gould. 2 shells.

Range: Kodiak Island to Puget Sound.

Genus Bullaria

Inhabits tropical to temperate waters at shallow depths.

One species, however, has been recorded from 1,181 fathoms.

1. *Bullaria gouldiana* Pilsbry. 20 shells.

Range: Santa Barbara, Calif., to Mazatlan, Mex.

Genus Terebra

Inhabiting warm waters at predominantly shallow depths although *T. nassula* Dall has been reported from 640 fathoms.

1. *Myurella armillata* Hinds. 2 shells.

Range: Abundant between Panama and Magdalena Bay in 5 to 13 fathoms.

2. *Myurella simplex* Carpenter. 2 shells.

Range: Neighborhood of Santa Barbara, Calif.

Genus Megasurcula

Inhabits the California coast.

1. *Megasurcula carpenteriana* Gabb. 3 shells.

Range: A "beach specimen" is reported by Gabb from San Diego.

Genus Olivella

Ranging from shallow to deep water, quite predominantly in southern habitats.

1. *Olivella biplicata fucana* Oldroyd. About 60 shells.

Range: Straits of San Juan de Fuca to San Diego, Calif.

2. *Olivella pedroana* Conrad. About 25 shells.

Range: Puget Sound to Cape San Lucas.

3. *Olivella boetica* Carpenter. About 50 shells.

Range: Kodiak Island to Cape San Lucas.

Genus Cypraeolina

Inhabits usually warmer waters.

1. *Cypraeolina pyriformis* Carpenter. 1 shell.

Range: Alaska to Mazatlan, Mexico.

Genus Kellettia

Inhabits the North Pacific Ocean.

1. *Kellettia kelletti* Forbes. 19 shells.

Range: Santa Barbara, Calif., to San Quintin Bay.

Genus Macron

Inhabits the California coast.

1. *Macron aethiops* Reeve. 24 shells.

Genus Aletrion

The genus *Nassa* Lamarck includes both shallow and moderately deep water species, those inhabiting shallow waters ranging farther north.

1. *Aletrion fossatus* Gould. 1 shell.

Range: Vancouver Islands to Cerros Islands, L. Calif.

2. *Aletrion mendicus* Gould. 1 shell.

Range: Kodiak Island to Magdalena Bay, L. Calif.

Genus Columbella

Living in shallow waters in all seas, but a greater number of species occurring in southern waters.

1. *Columbella carinata californiana* Gaskoin. 1 shell.

Range: Forrester Island, Alaska, to Salina Cruz, Mex.

Genus Murex

Inhabits warm and temperate waters at comparatively shallow depths.

1. *Murex festiva* Hinds. 48 shells.

Range: Santa Barbara, Calif., to Cerros Island, L. Calif.
Dredged from 7 fathoms on a sandy floor.

Genus Acanthina

Inhabits the west coast of America.

1. *Acanthina lugubris* Sowerby. 29 shells.

Range: San Diego, Calif., to Magdalena Bay, Calif.

Genus Forreria

Inhabits principally Arctic and Antarctic waters.

1. *Forreria belcheri* Hinds. 3 shells.

Range: San Pedro, Calif., to Scammon Lagoon, L. Calif.
Common at low water at San Diego.

Genus Bursa

Inhabits southern waters.

1. *Bursa californica* Hinds. 15 shells.

Range: Monterey, Calif., to Cerros Island, L. Calif.

Genus Bittium

Universally distributed in shallow water near the shore.

1. *Bittium quadrifilatum* Carpenter. 5 shells.

Range: Monterey, Calif., to San Ignacio Lagoon, L. Calif.

Genus Cerithidea

Inhabits shallow, usually subsaline, warmer waters.

1. *Cerithidea californica* Haldeman. 1 shell.

Range: Baulinas Bay to San Diego, Calif.

2. *Cerithidea mazatlanica* Carpenter. 2 shells.

Range: Mazatlan, Mexico.

Genus Caecum

Inhabits temperate and tropical seas.

1. *Micranellum clarki* Bartsch.

Genus Littorina

Inhabiting very shallow, warm to cool waters.

1. *Littorina planaxis* Philippi. 1 shell.

Range: Puget Sound to Magdalena Bay, L. Calif. Found in great numbers between tides on outcropping coarse granite, Bodega Bay, Calif.

Genus Rissoina

Inhabits usually very shallow temperate to warm waters.

1. *Rissoina pleistocena* Bartsch. 1 shell.

Genus Hipponix

Inhabits southern waters.

1. *Hipponix antiquatus* Linné. 1 shell.

Range: Crescent City, Calif., to Panama and the Galapagos Islands.

Genus Crepidula

Inhabiting shallow water, both cool and warm, but with a preference for the latter.

1. *Crepidula onyx* Sowerby. About 30 shells.

Range: Monterey, Calif., to Panama.

2. *Crepidula excavata* Broderip. 2 shells.

Range: Monterey, Calif., to Payta, Peru.

Genus Crucibulum

Ranging from shallow to moderately deep and from cool to warm water.

1. *Crucibulum spinosum* Sowerby. 1 shell.

Range: Trinidad, California to Tene, Chile and the Galapagos Islands.

Genus Polinices—Subgenus *Neverita*

Universally distributed. In shallow depths in its northern range, in deeper waters in its southern.

1. *Polinices recluzianus* Deshayes. 60 shells.
Range: Crescent City, Calif., to Tres Marias Islands.
2. *Polinices recluzianus imperforata* Stearns. 8 shells.
Range: Crescent City, Calif., to San Diego, Calif.
3. *Polinices recluzianus altus* Dall. 6 shells.
Range: Monterey, Calif., to Catalina Island, Calif.

Genus Acmaea

Inhabiting very shallow depths, ranging from boreal to warm waters.

1. *Acmaea persona* Eschscholtz. 1 shell.
Range: Schumagin Islands to Socorro Islands.

Genus Astraea

Living in southern waters.

1. *Astraea undosus* Wood. 36 shells.
Range: Laguna Beach, Calif., to Cerros Islands, L. Calif.

Genus Norrisia

Living on the coast of Southern California.

1. *Norrisia norrisi* Sowerby. 7 shells.
Range: Monterey, Calif., to Cerros Island, L. Calif.

Genus Tegula

Living on the west coast of North America.

1. *Tegula aureotincta* Forbes. 1 shell.
Range: Santa Barbara Islands, Calif., to Magdalena Bay, L. Calif.
2. *Tegula ligulata* Menke. 2 shells.

Range: Monterey, Calif., to Acapulco, Mexico.

Genus Calliostoma

Universally distributed in deeper water; below 50 fathoms in its southern range.

1. *Calliostoma costatum* Martyn. 1 shell.

Range: Sitka, Alaska, to San Diego, Calif.

Genus Haliotis

Inhabits warmer waters.

1. *Haliotis corrugata* Sowerby. Several Fragments.

Range: Monterey to San Quintin Bay. Below tide, on rocks, from San Diego, Calif., to San Pedro, Calif.

Genus Fissurella

Universally distributed except in arctic seas.

1. *Fissurella volcano* Reeve. 6 shells.

Range: Crescent City, Calif., to Panama.

Genus Megathura

1. *Megathura crenulata* Sowerby. 5 shells.

Range: Monterey, Calif., to Cerros Island.

Genus Megatebennus

1. *Megatebennus bimaculatus* Dall. 4 shells.

Range: Forrester Island, Alaska, to Cape San Lucas.

Genus Diodora

1. *Diodora aspera densicathrata* Reeve. 6 shells.

Range: Monterey, Calif., to San Quintin Bay, and Socorro Island.

DESCRIPTION OF NEW SPECIES

ORDER TELEODESMACEA

Superfamily ASTARTACEA

Family CRASSATELLIDAE

Genus CRASSATELLITES Krüger

Subgenus CRASSINELLA Guppy

Crassinella quintinensis Manger n. sp.

PLATE XXI, Figs. 1, 2

Only one right valve in the collection.

Shell very small, rounded triangular in outline, moderately thick, moderately inflated, nearly equilateral, height slightly less than length.

Beaks slightly anterior to center, flattened dorsally-ventrally, pointing backwards and upwards.

Dorsal margin declining at about 80° , the anterior dorsal margin convex, more so in the umbonal region, meeting the ventral margin in a rounded obtuse angle; posterior dorsal longer than the anterior, straight, excavated, meeting the ventral margin in a subrounded angle of little more than 90° ; ventral margin symmetrically, regularly convex.

Lunule narrow, obliquely flattened; escutcheon very wide, flattened horizontally, broadly semilanceolate in the right valve.

Sculpture of 13 prominent concentric ribs, more crowded ventrally.

Resilifer narrow, triangular, bounded posteriorly by a low ridge separating it from the ligamental area, upper margin flush with the dorsal margin of the shell.

Anterior adductor scar oval, posterior circular in outline.

Pallial line parallel with the margin, joining the muscle scars at the interior ventral position.

Length 7.9 mm., height 7.5 mm., semidiameter 2.3 mm.

Type: In U. S. Nat. Mus.

Type Locality: San Quintin Bay, Lower California.

One right valve from 11729.

Superfamily VENERACEA

Family VENERIDAE

Subfamily VENERINAE

Genus ANOMALOCARDIA Schumacher

Anomalocardia subrugosa Manger n. sp.

PLATE XXI, Figs. 3, 4

Shell small, moderately thick, inflated, roundly trigonal in outline, posteriorly-dorsally truncate, posteriorly longer, ratio of height to length about 1.04 : 1.

Beak between the median vertical and the anterior third, twisted forward and down, the tip slightly removed from the dorsal margin.

Dorsal margins closer to the beaks diverging at about 105° . Anterior dorsal margin straight for the distance of the lunule, oblique, descending more rapidly than the posterior dorsal, near its anterior end becoming horizontal. Anterior extremity narrowly rounded. Posterior dorsal margin slightly convex, subangled at the beginning of the posterior truncation; the truncation very slightly emarginate, sloping anteriorly upwards, the lower subangulation below the median horizontal, large, rounded; ventral margin rather evenly convex, ascending strongly anteriorly.

Dorsal area posteriorly shallowly furrowed. Lunule broadly semilanceolate (in the right valve), delimited by a sharply incised line, its surface smoother than that of the remainder of the shell. Ornamentation of many overturned lamellae some of which at irregular intervals are aggregated into coarse ribs. Ligament very narrow, short, separate from the overlying, rather deeply undercut dorsal shell margin by a narrow deep groove.

Hinge plate rather narrow, its ventral border sloping anteriorly; posterior right dorsal margin is grooved (to receive the edge of the opposite valve).

Teeth of right valve three. Dental formula R 010101; posterior cardinal of intermediate width and longest, centrally shallowly furrowed; central cardinal widest, highest, somewhat cuneate, shallowly, narrowly grooved posteriorly; anterior cardinal lowest, thinnest, diverging from the dorsal margin at a low angle. Central socket widest; anterior the longest.

Adductor scar large; posterior oblique, fig-shaped in outline; anterior subcircular. Pallial sinus very short, very narrowly triangular, about horizontal. Pallial line well removed from the ventral shell margin. Inner border of shell margin rather narrow; finely crenulated.

The right valve; length 18.7 mm., height 16.1 mm., semi-diameter 6.4 mm.

Type: In U. S. Nat. Mus.

Type Locality: San Quintin Bay, Lower California.

No minute rugosities are present on the (posterior) right nymph as reported by Dall for the section *Anomalocardia*. The sculpture is concentric, however, as in *Anomalocardia*.

This shell seems to be most closely related to *A. subimbricata* Sowerby. The spaces between the ribs in the latter species are smooth, whereas in the former they are roughened by concentric lamellae.

Occurrence: One right valve probably from San Quintin Bay, 11729.

Superfamily MACTRACEA

Family MACTRIDAE

Genus SPISULA Gray

Subgenus HEMIMACTRA Swainson

Section MACTROMERIS Conrad

Spisula (Mactromeris) hemphilli var. *orcutti* Manger n. var.

PLATE XXI, Figs. 5, 6

Shell large, trigonal to ovate-trigonal, moderately thick, high, nearly equilateral, pronouncedly inflated, ratio of length to height about 5 : 4.

Beaks prosogyrate, anterior to center, high, obtusely rounded, turned down more than 90° and slightly forward.

Anterior dorsal margin evenly concave; posterior dorsal margin gently convex, sloping somewhat more than the anterior; anterior margin narrowly rounded; posterior extremity obtusely, roundly angled, sometimes decidedly, sometimes hardly at all; ventral margin evenly and broadly rounded.

Posterior dorsal area bounded by a broad, flat, bi-angulated keel.

Lunule broadly cordate, each half concave. A narrow concave border along the dorsal margin near the beaks.

External surface with many small flat or slightly oblique incremental lamellae, crossed by faint radial threads.

Ligamental scar narrow, somewhat sagittal, surface sloping transversely, ventral border obtusely keeled; chondrophore curved, deep, rounded.

Hinge plate strongly bowed along its ventral border, not produced beyond the laterals anteriorly, slightly produced posteriorly.

Laterals short, parallel to the hinge margin, all about equal in length; anterior left higher than posterior, in line with the anterior cardinal arm but distinctly separated; anterior ventral lateral of the right valve likewise in line with the anterior cardinal arm, and distinctly separated from it.

Cardinal teeth not reaching more than half the distance to the ventral border of the hinge plate; arms of the right cardinal slightly longer than those of the left, not meeting dorsally, not so widely divergent, of equal length, the anterior slightly thicker; arms of left cardinal equally short and thick, joined dorsally, diverging at right angles.

Adductor scars above the median horizontally typically mactroid.

Pallial sinus small for the group, U-shaped, ascending.

Pallial line parallel with the ventral margin.

A right valve; length 128 mm., height 108 mm., semi-diameter 32.8 mm.

A left valve; length 137 mm., height 112 mm., semi-diameter 38.3 mm.

Type: In U. S. National Museum.

Type Locality: San Quintin Bay.

Orcutt includes the following note:

"Washed from bank of wharf, San Quintin Bay, Baja California. This variety I have not seen recorded, nor any *Spisula* fossil from San Q. No *Spisula* from Magdalena

Bay, Nautilus July/18. It differs from the typical hemphilli by being shorter, wider, thicker."

This shell is distinguished by the following:

Shell triangular, high, inflated.

Beaks anterior.

Cardinal arms diverging, intermediately between *S. longa* Dall and *S. planulata* Conrad; short.

Laterals short, anterior laterals dorsally and ventrally equal, separated from the cardinal arm; but the ventral anterior lateral in line with it. Posterior laterals about $1\frac{1}{2}$ times the anterior from the beaks.

The central bowing of the hinge plate under the chondrophore with a sinus on either side.

Pallial sinus short, ascending.

Pallial line not ascending.

Four valves from San Quintin Bay, 11729.

EXPLANATION OF PLATE XXI

Figs. 1, 2. *Crassinella quintinensis* Manger.

1, Exterior of right valve.

2, Interior of right valve.

Figs. 3, 4. *Anomalocardia subrugosa* Manger.

3, Interior of right valve.

4, Exterior of right valve.

Figs. 5, 6. *Spisula hemphilli* var. *orcutti* Manger.

5, Exterior of left valve.

6, Interior of right valve.



VITA

George Edward Manger was born in Baltimore, Maryland, August 17, 1902. After attending the public schools of that city, he received pre-collegiate training at the Baltimore City College. In 1919 he entered the Johns Hopkins University from which institution he received the degree of Bachelor of Arts in June, 1923. From September, 1923 to June, 1925 he was engaged in teaching chemistry, biology, and English in the high schools of Maryland; the first year at Hagerstown, the second at Easton.

In September, 1925 he returned to the Johns Hopkins University where for the next four years he has been engaged in graduate work in the Department of Geology.

During the field season of 1926 he was engaged with Dr. W. C. Alden of the United States Geological Survey in mapping and correlating the river terraces and Pleistocene mountain glaciers of Wyoming and portions of surrounding states.

The following season was spent with Dr. Frank Reeves of the United States Geological Survey in mapping the Big Snowy Mountains of Montana and with Mr. N. W. Bass in mapping Tertiary coal beds in the Tongue River valley in southeastern Montana. During the summer of 1928 he was employed in foraminiferal research by the Sinclair Exploration Company.

